REMARKS

Claims 1-5 and 11-24, as amended, appear in this application for the Examiner's review and consideration. Claims 1 and 16 have been amended to include the recitation that previously appeared in claims 6, namely, that the etching step comprises immersing the substrate into a bath that includes an etchant. No new matter has been added, so these claim changes and additions should be entered at this time. .

Claims 15 and 22 were rejected as allegedly presenting new matter due to the use of the term "approximately." In response, applicants have replaced that term with the term "about" which is equivalent but which is expressly supported in the specification.

The claims 1-6 were also rejected as the Examiner is unclear as to how the process of wet etching directly followed by an ozone treatment can produce an adhesive surface on the substrate. The applicants respectfully traverse this rejection, as it is clear from the application that an adhesive surface is that which is obtained by performing the steps of the current inventive method. In particular, after the surface is treated by wet chemical etching, the etched surface is brought directly into contact with a gaseous ozone atmosphere. The ozone reacts with the hydrogen on the wafer surface to form silanol sites on the surface (see page 6, lines 15-19 and Fig. 5 of the application). These silanol sites form an adhesive surface because they enable the surface to provide enhanced bonding to other wafer surfaces compared to a surface that is not treated as described herein. This is clearly understood by skilled artisans when reading the application as a whole and in particular with reference to page 6, lines 20-25 and Fig. 6.

In addition, it is clear from the description that the surface will be adhesive, meaning hydrophilic and dried, and the way to obtain such characteristics is to:

treat the surface by wet chemical etching to produce a surface that doe not contain an oxide layer and which is hydrophobic;

expose the etched surface to ozone to transform the hydrophobic surface into a hydrophilic surface, with the oxidation of the hydrogen groups present on the surface into hydroxyls; and

conduct the latter step in a closed atmosphere to provide the required concentration of ozone without contamination and especially to produce a dry surface due to saturation of sites surface.

These steps are explicitly recited in claim 1 and the resulting surface is ready for bonding with an other substrate: one skilled in the art would be able to deduce the role played by each step in this treatment.

Concerning the Examiner's allegation that the specification does not describe how an "adhesive layer" is form, it has to be notice that the specification is talking about a "adhesive surface" so that no layer per se has to be formed. By adhesive, it is clear that it is intended to mean a bondable surface according to the invention, i.e., dry and hydrophilic surface and low level of particle contamination.

In view of the above remarks, the applicant respectfully requests withdrawal of all of the 35 U.S.C. §112 rejections of the claims.

The claims were rejected for allegedly being unpatentable over the combination of published U.S. applications to US2003/0087532 to Wu et al. ("Wu") and US2002/0157686 to Kenny et al. ("Kenny") with the addition of US patent 6,330,713 to Geusic cited against certain dependent claims.

Claim 1 has been amended, and recites a method for producing an adhesive surface on a substrate that includes treating the surface by wet chemical etching with immersing of the substrate into a bath that includes an etchant to remove an oxide layer and to provide a hydrophobic surface, and then directly exposing the etched hydrophobic surface to a gaseous ozone atmosphere within a closed container to provide a dry hydrophilic surface.

In contrast, Wu pertains to a methodology for patterned oxide etching and subsequent removal of the patterned photoresist (see paragraph 0009). Wu teaches to use ozone to remove the photoresist pattern during a stripping step, and in a subsequent step to form a second oxide layer (see paragraphs 13 and 14). Wu fails to teach or suggest to directly expose the etched hydrophobic surface to a gaseous ozone atmosphere within a closed container to provide a dry hydrophilic surface, as recited in claim 1. Such a technique is advantageous because it minimizes the chances of recontamination of the surface, and because it results in an adhesive surface having a reduced particle concentration in comparison to a hydrophilic wafer surface produced in a wet manner (see application, page 3, lines 24-27).

Accordingly, Wu discloses a process for the treatment of oxides on a substrate. More specifically, Wu discloses in a first embodiment a method of oxide stripping/photoresist etching that includes:

forming a patterned photoresist over a first oxide layer, and locally etching the exposed oxide using an HF solution;

typically, the etching step is followed by a rinse step; and

removing the patterned photoresist layer by spraying ozone.

According to a second embodiment, the oxide stripping/photoresist etching steps are followed by a particle removal step, since it appears that the preceding steps involve particle contamination. The particle removal steps include the following features:

treatment by dilute HF followed by an ozone treatment;

the steps being performed in the same tool.

Further, Wu provides five examples of his treatment, none of which relate to the present invention. In examples 1, 2, 4, and 5 the HF treatment performed to etch the exposed oxide (according to the first aspect identified below) is followed by a rinse with deionized water, and in examples 1-3, the HF treatment is NOT followed by an ozone treatment. Example 4, clearly shows that oxide stripping/photoresist etching step involves particle contamination. Example 5 details particle removal treatment according to the second embodiment of the invention. It also include a deionized water rinse after HF is dispensed on the wafer, and before ozone water is dispensed on the wafer. Thus, none of these examples teaches the claimed invention, namely, treating the surface by wet chemical etching that comprises immersing the substrate into a bath that includes an etchant to remove an oxide layer and to provide a hydrophobic surface; and directly exposing the etched hydrophobic surface to a gaseous ozone atmosphere within a closed container to provide a dry hydrophilic surface.

In contrast, the two embodiments disclosed in Wu, although they may seem related because they both are based on deoxidation (HF) and oxidation (ozone) steps, are in fact directed to two different technical areas. The first embodiment cannot be considered relevant to the invention because the induced particle contamination would not provide an adhesive or bondable surface due to the contamination of the surface by the particles. It is in particular well known that bonding requires a perfect particle free surface (see Maleville article "Detailed characterization of wafer bonding," copy enclosed). In addition, it is clear from many passages in the text and the figures of Wu that the treatment of the first embodiment is performed locally and selectively on the wafer (because of the presence of

the photoresist mask), so that Wu does not disclose a process for providing a surface that is uniformly treated and suitable for bonding.

The second embodiment of Wu is closer to the teachings of the present invention in that it aims at a particle removal step that would form an hydrophilic surface, but there are significant differences between Wu's disclosure and the presently claimed invention. Wu's HF step is not performed by immersing the wafer in a bath. For this embodiment, Wu is silent on how the HF treatment step is performed. In example 5, the HF step is performed by spraying a HF solution on the surface of the wafer. This does not obtain a uniform treatment of the surface since it depends on how the spray is applied. Furthermore, the ozone step is not performed directly after the HF step. In particular, example 5 adds a rinsing step in-between those two steps. In other passages, Wu is silent on the fact that an intermediate step is present between etching and oxidation. Also, Wu's ozone step is not performed by exposing the wafer to an ozone gas specifically. Although introduction of ozone as a gas is recited in Wu, this is only one of many possibilities, and certainly it is not the preferred one. Wu's preferred ozone application is by spraying a dilute solution on the wafer surface. The advantage in the present invention of applying ozone gas is to provide a dry hydrophilic surface. The application of ozone in solution would not provide a dry surface and the presence of water at the surface of the wafer would be detrimental to the bonding quality as explained in the present application. It should also be noted here that individual steps of the claimed invention (immersion in bath of HF and/or exposure to an ozone atmosphere) are effectively known in the prior art. What however is claimed is the specific and direct combination of those two steps to provide a bondable surface. This is not taught by Wu or any other prior art reference.

Kenny specifically discloses a system for cleaning a workpiece or wafer by forming a boundary layer of heated liquid on the workpiece surface. Ozone is also provided around the workpiece. The ozone diffuses through the boundary layer and chemically reacts with contaminants on the workpiece surface. A jet of high velocity heated liquid is directed against the workpiece to physically dislodge or remove a contaminant from the workpiece. The jet penetrates through the boundary layer at the point of impact, but the boundary layer otherwise remains largely undisturbed. Preferably, the liquid includes water, and may also include a chemical. Steam may also be jetted onto the workpiece, with the steam also physically removing contaminants, and also heating the workpiece to speed up chemical

cleaning. The workpiece and the jet of liquid are moved relative to each other, so that substantially all areas of the workpiece surface facing the jet are exposed at least momentarily to the jet.

Thus, Kenny requires the formation of a liquid boundary layer on a wafer using ozone in the atmosphere of the process chamber. Contact of ozone with the wafer surface is performed through diffusion of ozone in the liquid interface layer. As in Wu, there is no exposure of the wafer to an gaseous ozone atmosphere that would form a dry hydrophilic surface as in the presently claimed invention. Kenny teaches away from this when he explains that if the surface of the wafer is dry, a liquid is sprayed "to remain the surface wetted at all time". This is in direct contradiction to the present claims which require a dry hydrophilic surface. Additionally, as previously noted, there is no disclosure in Kenny of immersion of the wafer in a bath of etchant, but only formation of a surface liquid layer.

Also, Kenny specifically noticed that the way the chemistry is applied is as relevant as the nature of the chemistry itself , so that immersion in HF bath plus exposure to gaseous ozone of the present invention cannot be found equivalent to the method disclosed in Kenny. Thus, the invention is not taught by or inherently provided by the combination of Wu and Kenny and all rejections based on this combination of references should be withdrawn.

Geusic discloses a method for bonding two wafers using annealing process. The method is used for bonding one semiconductor surface to a second semiconductor surface. The semiconductor surfaces are annealed with an energy source wherein energy is confined only to the semiconductor surfaces. The annealed surfaces are then bonded to each other. This patent does not remedy the deficiencies of Wu, Kenny, or the combination of Wu and Kenny. It appears to be cited as a disclosure of a closed container, but the container of Geusic is used for an entirely different purpose than Wu or Kenny. In particular, the two primary documents do not suggest or disclose that the wafers to be bonded together have a dry hydrophilic surface directly in contact with an ozone atmosphere after being taking out of the bath of etchant, so the fact that Geusic may have some sort of closed container is not relevant to the other disclosures.

In view of the above amendments and remarks, the applicant respectfully requests withdrawal of all of the 35 U.S.C. §§112, 102(e) and 103(a) rejections of the claims. The applicant also respectfully submits that the entire application is in condition for allowance,

early notice of which would be appreciated. Should the Examiner not agree that all pending claims are allowable, then a personal or telephonic interview is respectfully requested to discuss any remaining issues and expedite the eventual allowance of these claims.

Finally, a substitute PTO 1449 is enclosed. Typographical errors have been corrected in the description of references AH, AK and AL. Applicants would appreciate the Examiner's cooperation in acknowledging this form and substituting it for the current form that was already acknowledged.

Respectfully submitted,

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